To validate and confirm the analysis performed, and presented above, various experiments were performed. The experiments were directed to determining the influence of a number of factors on EFL, including the influence of time on the reel, use of foam pads, constant and variable take-up tension, and variation in the line speed or angular velocity of
5   the spool on the distribution of EFL in buffer tubes.

One of the first experiments conducted was the influence of the time the buffer tube stands on the reel after manufacture. Analysis of the EFL distribution in three 3-km long buffer tubes was performed. Results are summarized in Figure 33 and Table I (shown below). The end points of lines 1*, 2*, and 3* were obtained the same day that the tubes
10   were fabricated. Curves 1*-3* show the EFL distribution that was obtained when the tubes were cut and measured ten days later.

The curve 1* in Figure 33 was obtained from a buffer tube that was not reeled on the spool. Instead, the buffer tube was placed in a box where it cooled to the room temperature. Variation of EFL in this case is from 0.60% to 0.69% without a clear "parabolic" distribution
15   typical for reeled buffer tube.

The curve 2* corresponds to the case when the buffer tube was placed in the box for 7 days, then reeled under 1.5kg tension on the reel, kept on the reel for 3 days, then unwrapped for an EFL measurement. This curve has features of a parabolic shape with 0.38% EFL at the beginning of the buffer tube, up to 0.57% in the middle, and 0.34% on the end of the buffer
20   tube. Curve 2* is located below Curve 1*. The reduction in the levels of EFL is apparently due to the action of the circumferential forces of tension in the reeled buffer tube causing 3-day elongation (creep) of the polymeric material with respect to the fibers.

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The parabolic-type curve 3* is located below curves 1* and 2*, apparently due to increased time (10 days) of stretching of the rolled buffer tube by circumferential stresses. The EFL values are ranging from –0.02% EFL at the beginning of the buffer tube, to 0.24% in the middle, and 0.10% on the end of the buffer tube.

5   Comparison of the curves obtained the same day and 10 days after fabrication of buffer tubes suggested the following. In the reeled tubes EFL reduced while in unreeled tubes EFL increased in time. This can be related to the thermal cooling and shrinkage of thermoplastic materials; in the reeled tubes the shrinkage is restricted by existing circumferential stresses. When the contribution from the stresses is higher than that of residual shrinkage, relative elongation of thermoplastic materials is higher than shrinkage. Consequently, the resulting elongation would result in a reduction of EFL. In contrast, in unreeled buffer tubes, the residual shrinkage is not restrained and final values of EFL increase.

Sample	Measure- ment time (days)	Sample Location (m)	Average EFL in Tube 0 (mm)	Average EFL in Tube 1 (mm)	Average EFL in Tube 2 (mm)	Average EFL in Tube 3 (mm)	Average EFL in Tube 0	Average EFL in Tube 1	Average EFL in Tube 2	Average EFL in Tube 3
OSE	0	3000		18.6	16.0	10.4		0.61%	0.52%	0.34%
ISE-1	0	0	4.1	14.5	14.7		0.13%	0.47%	0.48%	
ISE-2	7	0	5.9				0.19%			
1	10	0		19.8	11.5	-0.6		0.65%	0.38%	-0.02%
2	10	300		20.5	13.2	2.3		0.67%	0.43%	0.08%
3	10	600		20.5	14.0	5.2		0.67%	0.46%	0.17%
4	10	900		18.3	13.9	3.3		0.60%	0.46%	0.11%
5	10	1200		19.8	16.0	6.5		0.65%	0.53%	0.21%
6	10	1500		19.5	16.4	7.3		0.64%	0.54%	0.24%
7	10	1800		20.4	17.4	7.3		0.67%	0.57%	0.24%
8	10	2100		18.4	16.6	7.1		0.60%	0.54%	0.23%
9	10	2400		20.1	13.4	6.2		0.66%	0.44%	0.20%
10	10	2700		19.9	11.8	7.8		0.65%	0.39%	0.26%

11	10	3000		20.9	10.5	3.1		0.69%	0.34%	0.10%

Table I: Measured Values of EFL in Three Buffer Tubes.

Monotonic reduction in take-up tension should result in a flatter distribution of circumferential stresses in the roll. Consequently, changes in EFL are expected to be within a narrower range as compared to the case of constant take-up tension. In addition, finite element modeling showed that adding a soft foam pad on the core or periodically inserting soft pads into the roll should increase the range of variation of EFL.

Experiments were performed on the 12-km buffer tubes. The first buffer tube was wrapped around a spool at a constant take-up tension. The corresponding EFL curve is shown in Figure 34. The second buffer tube was reeled on the same spool but with a double-layer of thick foam on the core. Also, in the case of the second buffer tube, the take-up tension was monotonically reduced from 25N to approximately 9N. The corresponding EFL curve is shown in Figure 34. As can be seen from Figure 34, the parabolic curve typical for reeled buffer tubes on a bare reel is actually shallower than the curve obtained with a pad and variable take-up tension. Based on these results, it was suggested to further study the possible nonlinear effect of a thinner soft pad on initial values of EFL toward the goal of obtaining a flatter curve.

Figure 35 illustrates an approach using a thin foam layer on the "regular-rigidity" core and decaying take-up tension to minimize the variation in the EFL values.

Typically, reeling is performed at a constant line speed, i.e. constant angular velocity of the rotating spool. As described previously, a variation in the line speed and the corresponding variation in angular velocity of the reel produces variations along the radius of the buffer tube roll in temperature and possibly tensile load. This resulted in the concept of